NASA SUSPENDED LOAD OPERATION ANALYSIS/APPROVAL

OPERATION - Scout Fourth Stage Buildup and Dynamic Balance

SUPPORTING DOCUMENTS - The associated operational procedures and System Assurance Analysis (SAA) are as follows:

- SOP 5-5-5, Fourth Stage Buildup and Dynamic Balance (Primary Method)
- SOP 5-5-1, Fourth Stage Buildup and Dynamic Balance (Alternate Method)
- SAA88CR000-040 (September 1990), 1-Ton Bridge Crane, Spin Test Building No. 995, Vandenberg Air Force Base

GENERAL DESCRIPTION - Personnel are required to be directly under a suspended Scout Altair III fourth stage rocket motor. The suspended load tasks are as follows:

1. BREAKOVER OF THE ROCKET MOTOR ASSEMBLY: 2 personnel working partially under the suspended motor assembly remove the fixture locking pins and manually rotate the motor assembly from a horizontal to a vertical position and reinstall the locking pins. Approximately 2 minutes are required for this operation.

2. REMOVAL OF THE AFT END OF THE TURNOVER FIXTURE: With the assembly suspended, 1 person is required to reach his/her hands under the suspended load to unbolt the aft end of the turnover fixture. Approximately 15 minutes are required for this operation.

3. INSPECTION OF THE HELI-COILS: With the assembly suspended, 1 person is required to inspect the heli-coils in the motor aft thrust flange prior to installation on the spin table adapter. This requires looking on the bottom side of the suspended load and may require reaching under the load with the hand to feel for damage. Approximately 5 minutes are required for this operation.

4. INSTALLATION OF THE MOTOR ON THE ADAPTER: After breakover, removal of the aft turnover fixture, and inspection of the heli-coils, the motor assembly is moved to the spin table and installed by bolting the aft thrust flange to an adapter section installed on the table. Close clearances between the rocket motor nozzle and the adapter require close monitoring by 2 personnel to avoid harming the easily-damaged flight-critical motor nozzle. This task requires

reaching under the suspended load to install the alignment pins and may require briefly extending a hand under the load to verify proper clearances during mating with the adapter. The whole operation requires approximately 20 minutes. Removal of the motor requires a reversal of these procedures. For a standard Scout operational flow, the motor is installed and removed once for motor balancing, once for shimming and balance check on the flight adapter, and once for payload balance operations for a total of three complete cycles. In addition, the motor may be temporarily unbolted and suspended just above the adapter for brief periods for shim installation between the motor and the adapter.

RATIONALE/ANALYSIS - The suspended load tasks comply with the NASA Alternate Standard as follows:

Alternate Standard Requirement #1a - These operations cannot be conducted without placing personnel beneath the suspended Scout rocket motor. The lifting operations described have been evaluated and found to have no operational means to eliminate personnel from working under the suspended load. Redesign of the existing rocket motors and associated lifting equipment is not feasible.

Alternate Standard Requirement #1b - The possible use of a secondary support system to catch the load in the event of a failure was analyzed. It was determined that the use of a secondary support system was not feasible because there is no means of supporting the motor vertically with the aft thrust flange exposed as required, other than with the hoist assembly.

Alternate Standard Requirement #1c - The maximum number of personnel permitted under the suspended load is 2, for breakover of the rocket motor assembly and installation of the motor on the adapter.

Alternate Standard Requirement #1d - Personnel required under the load will perform the suspended load operations as quickly as possible (reference General Description, items 1-4, page 1). Upon completion of the task, personnel will immediately move from under the load to outside the safety control area.

Alternate Standard Requirement #4 - SOP's 5-5-1 and 5-5-5 have been revised to permit only the approved number of persons under the suspended loads. The SOP's are available on site for inspection during the operation.

Alternate Standard Requirement #6 - Suspended load operations associated with hoisting the Scout fourth stage involve the Building 992 1-ton bridge crane. The crane is designed, tested, inspected, maintained, and operated in accordance with the NASA Safety Standard for Lifting Devices and Equipment, NSS/GO-1740.9. The crane is designed to meet a 5 to 1 safety factor based on ultimate strength for the hoist load bearing components.

Alternate Standard Requirement #1a (continued)

The use of a secondary support system was also investigated. This would require supporting the motor through the aft thrust flange; however, the flange must be exposed for heli-coil inspection and installation of the motor on the spin table. Because there is no other means to support the motor other than through the thrust flange, the rocket would have to be redesigned to eliminate personnel from working under suspended loads.

The Building 995 1-ton crane hoist is equipped with an electromagnetic holding brake and a worm gear for load braking. The hoist is being used to lift 700 lbs (35% of capacity) during suspended load operations.

The crane is load tested annually at 100% of rated capacity and at 110% of the weight to be lifted within 30 days of the lift. Detailed preventive maintenance is performed monthly, quarterly, and annually on the crane to ensure proper operation. A detailed inspection of the lifting sling is performed before each use. Nondestructive evaluation of the crane hook is performed annually. The wire rope is inspected monthly for discrepancies.

Alternate Standard Requirement #7 - A System Assurance Analysis (SAA) has been completed on the 1-ton bridge crane in Building 995. The SAA includes a failure modes and effects analysis/critical items list (FMEA/CIL) and a hazard analysis (see supporting documents).

The SAA identified two single failure points (SFP's), the hoist transmission (transmits power and reduces rotational speed from the hoist motor to the drum) and the electromagnetic holding brake. Failure of the transmission caused by broken teeth or failure of the holding brake to engage would result in the load dropping which could cause loss of life and/or flight hardware.

There is no history of failure with the SFP's in the critical failure mode. The transmission is visually inspected prior to each use for evidence of leaks or cracks and the oil level is verified quarterly and sampled annually. The brake is verified operational each day before use. The use of high-quality, reliable components and a comprehensive maintenance, inspection, and test program (including preoperational checks) ensures that the crane systems operate properly.

The associated SAA CIL sheets for the 1-ton bridge crane in Building 995 (pages 43-47) identify all the rationale for accepting the risk of the SFP's including design information, failure history, and the operational controls in place to minimize the risks (maintenance, inspection, test, etc.).

Alternate Standard Requirement #8 - Visual inspection (for cracks or other signs of damage or anomalies) of the lifting equipment and crane functional checks are performed before each use per NSS/GO1740.9.

Alternate Standard Requirement #9 - Trained and licensed crane operators shall remain at the hoist controls while personnel are under the load.

Alternate Standard Requirement #10 - Appropriate safety control areas are established before initiating operations. Only the minimum number of people (manloaded in the procedure) will be permitted in the control area. All other personnel remain outside this area.

Alternate Standard Requirement #11 - A pretask briefing and a safety walkdown of the area are conducted prior to the lift to ensure that all systems and personnel are ready to support. All participants are instructed on their specific tasks and warned of any hazards involved. Following any crew change, the new personnel are instructed by the task leader on their specific tasks and warned of any hazards involved.

Alternate Standard Requirement #12 - Personnel beneath the suspended load will be in voice and visual contact with the hoist operator/task leader. Upon loss of communication, the operations shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

Alternate Standard Requirement #13 - Personnel working beneath the load shall be in continuous sight of the hoist operator, task leader.

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